July 2003

U.S. Department of Homeland Security
U.S. Coast Guard (USCG)
Research and Development Center (R&DC)
1082 Shennecossett Road
Groton, CT 06340-6096

REPORT REFERENCE GUIDE

Publishing Standards for R&D Research Reports

USCG Research and Development Center reports provide a permanent record of the research, development, test and evaluation efforts we have conducted. These reports communicate results to customers, stakeholders and other researchers. R&DC reports should provide a description of the study objectives, methodology used, data analysis and conclusions.

This *Reference Guide (RG)* is intended for producers of R&DC research and development reports. As an aid to the individuals and organizations producing reports for R&DC, this Reference Guide includes on-line versions of standard publication materials (report cover, notice page, documentation page) available for review and downloading. This RG is a companion guide to DOT Order 1700.18B (Acquisition, Publication and Dissemination of DOT Scientific and Technical Reports), and updates/highlights the editorial and formatting rules from DOT-TST-75-97/PB 245400 dated May 1975, entitled, "Standards for the Preparation and Publication of DOT Scientific and Technical Reports (appendix to DOT Order 1700.18B)." Note that important excerpts from these instructions are provided in this reference guide. DOT Order 1700.18B, "Acquisition, Publication and Dissemination of DOT Scientific and Technical Reports," is cited in contracts as the required policy for the acquisition, publishing format, and dissemination of scientific and technical reports.

REPORT PREPARATION

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EXCERPTS FROM DOT ORDER 1700.18B, APPENDIX DOT-TST-75-97/PB 245400 DATED MAY 1975.

Copyright. No copyrighted material may be incorporated into a report unless written permission of the copyright owner has been obtained. Prior use of copyrighted material in another Government publication does not necessarily constitute permission to use it in a DOT publication. Where permission has been obtained and the material is used in a report, it shall be identified by a statement substantially as follows:

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Unpublished work may be protected under common law or equity even though there is no copyright notice. Problems relating to the protection given to unpublished work will be referred to the Office of the General Counsel.

Privately Owned Information: To avoid restriction on availability of reports, every effort should be made to avoid the use of proprietary information accepted by the Government for limited purposes. Such proprietary information will be used only if it is essential to the understanding of a report and only after approval by the Office of the General Counsel. Reports containing such proprietary information will bear a statement restricting availability and handling, as required; (see Distribution Statement below).

- Distribution Statement. Each DOT sponsoring element shall assign a distribution statement, which is placed on the cover and printed on all copies. The statement that appears on the cover must also appear in Block 18 of the Technical Report Documentation Page. Use one of the following as appropriate:

  (a) Document is available to the U.S. public through the National Technical Information Service, Springfield, VA 22161.

  (b) Approved for U.S. Government only. This document is exempted from public availability because (fill in reason). Transmittal of this document outside the U.S. Government must have prior approval of the (fill in DOT sponsoring element).

  (c) Approved for (fill in DOT sponsoring operating element) only. This document is exempted from public availability because (fill in reason). Transmittal of this document outside the (fill in sponsoring operating element), Department of Transportation must have prior approval of the (fill in responsible office).

Data Use Restriction: In the event that the Contractor furnishes any information or data which the Contractor considers to be proprietary under the terms of the contract, the Contractor shall affix the following use restriction legend to such proprietary data, shall mark such data with the number of the prime contract, and subcontract, if applicable; and shall deliver such proprietary data directly to the Government. No other legend is authorized and the Government will thereafter treat the data in accordance with such legend.

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> These data, furnished under U.S. Government Contract No. _____, may be duplicated and used by the Government with the express limitations that the data may not be disclosed outside the Government, nor be used for purposes of manufacture, without prior permission of the contractor. These restrictions do not limit the Government's rights to use or disclose any data obtained from another source without restriction. This legend shall be marked on any reproduction of these data in whole or in part.

Trademarks: The term "trademark" includes any word, name, symbol, device or any combination thereof, adopted and used by a manufacturer or merchant to identify his goods and distinguish them from those manufactured and/or sold by others. It is improper to use a "trademark" to identify goods not manufactured or sold by the owner of a trademark or his licensee. In general, the use of trademarks is discouraged. Where feasible, goods should be identified by a type designation or a structural feature that distinguishes them from other goods.

Trade Names and Manufacturer's Names: Particularly to be avoided is the appearance of endorsing or favoring a commercial product, commodity or service. Trade names or the names of manufacturers will not be given unless the report will not contain meaningful information without them.

ORDER OF ELEMENTS FOR R&D REPORTS (Not all elements are necessarily used in a report)

Front Matter

- Front Cover
- Notice/Disclaimer Page
- Technical Report Documentation Page
- Acknowledgements (not required)
- Executive Summary
- Table of Contents
- List of Illustrations
- List of Tables

- List of Acronyms, Abbreviations and/or Symbols (not required, but should be used if acronyms, abbreviations and/or symbols are numerous)

Report Body

Introduction
Main Text
Conclusions
Recommendations

Reference Material

References/Bibliography
Appendices
Index

FRONT MATTER

- **Report Cover** REPORT_COVER The cover page is not numbered.

- **Disclaimer/Notice Page** NOTICE_PAGE (Page ii)

- **Technical Report Documentation Page**
  TECHNICAL_REPORT_DOCUMENTATION_PAGE(Page iii)

INSTRUCTIONS FOR FILLING OUT TECHNICAL REPORT DOCUMENTATION PAGE:

Make items 4, 5, 12, 13, and 18 agree with the corresponding information on the report cover. Use all capital letters for main title (Item 4). Leave items 1, 2, 3, 10, and 22 blank. Complete the remaining items as follows:

6. This block shall contain the project number and Unique Deliverable Identifier (UDI) number (e.g., 1012.3.4 / UDI 00). For reports prepared by contractors, the project number and UDI number will be supplied by the R&DC COTR.

7. Author(s) name.

8. Performing Organization Report No.: For reports prepared by contractors, the R&DC number will be supplied by the R&DC COTR.

9. Performing Organization Name and Address (use zip code). Note: For reports prepared by contractors, both the contractor's organization and the USCG Research and Development Center will appear in this block.

11. Contract or Grant No. Insert the number of the contract or grant under which the report was prepared.

14. Sponsoring Agency Code. This block shall contain the Coast Guard sponsor's name and address. If a Headquarters'element, provide three-letter office designation (e.g., Commandant (G-MSE). For reports prepared by contractors, this information will be provided to the contractor by R&DC COTR.

15. Supplementary Notes. For reports prepared by contractors, this information will be provided to the contractor by R&DC COTR.

16. Abstract. Include a brief (NOT TO EXCEED 200 WORDS) factual summary of the most significant information contained in the report. An abstract should state the purpose, methods, results, and conclusions of the work effort. For the purpose, include a statement of goals (objectives, aims). For methods, include experimental techniques or the means by which the results were obtained. Results (findings) are the most important part of the abstract and selection should be based on one, or several of the following: new and verified events, findings of permanent value, significant findings which contradict previous theories, or findings which the author knows are relevant to a practical problem. Conclusions should deal with the implications of the findings and how they tie in with studies in related fields. Do not repeat title or other items provided on this page. When a report consists of a number of volumes, include the title of each of the other volumes in each abstract.

17. Key Words. Select specific and precise terms or short phrases that identify the principal subjects covered in the report. Key words shall conform to standard terminology, such as that given in the Defense Technical Information Center Thesaurus, October 1996, AD-A321038.

18. Distribution Statement: Note distribution statements on page three of this reference guide.

19. Security Classification (of report): Most reports will be UNCLASSIFIED. Note: Reports carrying a security classification will require additional markings giving security and downgrading information as specified by the sponsoring element. Refer to COTR for specific instructions.

20. Security Classification (of this page). Because this page may be used in preparing announcements, bibliographies, and databases, it should be unclassified, if possible. If a classification is required, identify the classified items on the page by an appropriate symbol. Refer to COTR for specific instructions.

21. No. of Pages. Insert the number of pages having printed material, including front and inside covers.

Measurements: All research reports should provide units of measurement using the SI (metric) system. Exceptions are allowed in special circumstances where international practice is to use non-metric values.

- **Table of Contents**.

  A Table of Contents is required for reports of 10 pages or more.

  The Table of Contents should start with the Executive Summary and list the body of the text from page one (1) through the last section of the report.

  Each heading level of hierarchy must consistently use a particular format style, such as all capitals, bold, underlining, etc. The wording of these heading levels shall be the same in the Table of Contents as in the text.

- **List of Illustrations.** List figure number, legend, and page number of each illustration. Abbreviate lengthy legends.

- **List of Tables.** List table number, legend, and page number of each table. Abbreviate lengthy legends.

- **List of Acronyms/List of Symbols.** (if necessary) – Define symbols and abbreviations where first introduced in the text, such as U.S. Coast Guard (USCG). When symbols and abbreviations are numerous, furnish a separate list of definitions. If a list is used, include organization symbols, e.g., ANSI, IEEE, etc.

- **Executive Summary.** (1–3 pages) The Executive Summary shall be written for the lay person; a person who does not know why the study was conducted, the technical areas being discussed, nor the implications of the results. Be sure to provide this background information to the reader. The Executive Summary should focus on a non-technical overview of the problem statement and conclusions, focusing the discussion on the advantages and limitations of the findings. SAMPLE
-

BODY OF REPORT

The body of the report should consist of:

- Introduction – may be more than one section
- Main Text – may be more than one section
- Conclusions
- Recommendations

(1) **General**. The contents and organization of the body of a report shall be determined by the nature of the work. However, limit the contents of that information required by the sponsoring organization to inform the reader. Eliminate unnecessary details and appendices. Start the first section on a right-hand page. This section usually provides work objectives and background information. Succeeding sections describe work procedures, apparatus/equipment involved, tests performed, results achieved, and related matters, as appropriate. The terminal sections of the main body of the report usually present conclusions and recommendations.

(2) **Headings**. Headings shall stand out from the text with their relative importance apparent.

(3) **Numbering System**. Number headings and paragraphs only when the numbers are needed for clarity or when extensive cross-references are used.

REFERENCE MATERIAL:

- **References, Bibliography, and Footnotes**. References should be cited in the text at the appropriate location by putting the name followed by the year in parentheses (Smith, 1998).

References should be included alphabetically by author in a reference list in the back of the report. Entries should be presented in a consistent format, with complete identifying data, in complete bibliographic format. Each entry should include authors, title, sources, identifying numbers, page number(s), and dates. Abbreviations are not recommended and should be used sparingly. References shall be consistent in formatting and punctuation. Use the following examples as guidance when citing references.

1. Journal Article (one author)

Szakonyi, R.. (1998). Leading R&D: how much progress in 10 years?. Research•Technology Management, Vol. 41, No. 6, p. 25-29.

2. Journal Article (more than one author)

Haerr, D., Harmon, L., & Bokelman, A. (1997). Transitioning the GPS operational control segment to a modern architecture. Navigation, Journal of the Institute of Navigation, Vol. 44, No. 2, p. 153-162.

3. Magazine Article

Halpern, M. (1998, November). Pushing the design envelope with CAE. Mechanical Engineering, p. 66-71.

4. Book (Jr. in Name)

Strunk, W., Jr., & White, E. B. (1979). The elements of style (3rd ed.). New York: Macmillan.

5. Report available from the National Technical Information Service (NTIS)

Beck, G., Beyler, C., DiNenno, P., Hansen, R., Waller, D., & Zalosh, R. (1997). An evaluation of the International Maritime Organization's gaseous agents test protocol (CG-D-24-97). Groton, CT: USCG Research & Development Center. (NTIS No. AD-A. 331924).

6. Proceedings Published Annually

Hansen, K.A. (1997). Nondestructive testing of wooden vessels. Oceans '97 MTS/IEEE Conference Proceedings, Vol. 2 of 2, p. 1173-1187.

7. Unpublished Work (not submitted for publication)

Summers, V., Allen, S., & Hansen, R. (1997). Management of change in an educational environment. Unpublished work. University of Connecticut at Avery Point.

8. Work in Progress (prior to publication)

Smith, N. A. (1998). The environmental impact of home fuel cell technology. Manuscript submitted for publication. University of Connecticut at Avery Point.

9. For on-line sources:

Author, (date). Title of Article. Name of Periodical or Source [On-line], Available: Specify path.

U.S. Environmental Protection Agency, Federal Remediation Technologies Roundtable, Site Remediation Technology InfoBase: A Guide to Federal Programs, Information Resources, and Publications on Contaminated Site Cleanup Technologies, First Edition EPA/542/B-98/006, August, 1998 [On-line], Available http://www.frtr.gov/pubs.html.

- **Appendices** - Start an appendix on a right-hand page. Do not use a separate page to announce an appendix; rather, the appendix identification should appear at the top of the page with the content starting immediately on the same page. Each appendix shall be cited in the table of contents, e.g., Appendix A – appendix title, Appendix B – appendix title, etc. When more than one appendix is used, designate them Appendix A, Appendix B, etc.

- **Index** – If an index is included for a lengthy report, make it as complete as the nature of the report and its probable usage requires.

ILLUSTRATIONS.

General. Treat illustrations consistently throughout a report. Locate illustrations after and near the first text reference made to them except in special situations, such as when a report contains only a few text pages and many illustrations; in such cases, place the illustrations in numerical sequence in the back of the report. It is preferable that illustrations be placed so that they may be viewed without turning the page sideways. If an illustration has to be placed sideways on a page, orient it so that the top of the illustration is at the left side of the page. Captions for illustrations should be centered underneath the illustration horizontally, unboxed. Make captions consistent in size and typeface throughout the report.

Color. Color enhancement of a photograph, sketch, graph or chart will only be authorized if it is essential to the unambiguous interpretation of the information presented. Often screens, cross-hatching, pattern lines, reverses, dots or similar techniques can be used as effective substitutes for color. RDC staff and contractors should minimize the use of color in all reports.

Fold-ins. Wherever possible, avoid the use of oversize illustrations that must be folded. Often most large illustrations can be planned for facing pages. When used, fold-ins should be presented on a right-hand page.

Numbering. Number illustrations to which reference is made in the text consecutively in Arabic numeral, preceded by the word "Figure" – for example, Figure 1., Figure 2., Figure 1-1, Figure 1-2, etc. All figures must be numbered in a single sequence from the beginning to the end of the report, excluding appendices. Number illustrations within appendices in a manner consistent with the appendix letter, such as Figure A-1., Figure B-2., etc. If only one appendix, use Figure A-1., etc. Example of a figure caption follows:

Figure 1. This is an example of the proper formatting of a figure caption (centering, punctuation and capitalization).

TABLES:

General. Tables should be as simple as possible so that the reader can easily grasp the meaning of the data.

Placement. Locate tables after and near the first text reference made to them, except in special situations such as when a report contains only a few text pages and many tables. It is preferable that tables be placed so that they may be viewed without turning the page sideways. If a table has to be located sideways on a page, orient it so that the top of the table is at the left side of the page.

Headings/Columns. Give repetitive unit of measure or degree in the column headings of tables. Do not repeat in the columns. When tables continue on two or more pages, note the continuation and repeat the table and column headings and rulings on each page.

Numbering. Number tables to which reference is made in the text consecutively in Arabic numerals, preceded by the word Table; for example, Table 1, Table 2, Table 1-1, Table 2-1, etc. All tables must be numbered in a single sequence from the beginning to the end of the body of the report. Number tables within appendices in a manner consistent with the Appendix letter, such as "Table A-1, Table B-1, etc.

Captions. Give each table a descriptive caption following the table number. Place caption centered above table.

Example of a table caption follows:

Table 1. This is an example of the proper formatting of a table caption, (centering, punctuation and capitalization).

EQUATIONS.

General. Identify symbols after first use or in a separate list. Make opening and closing parentheses, brackets, and braces the same height as the tallest expression they enclose. Separate numerator from the denominator with a line as long as the longer of the two. Center both numerator and denominator on the line.

Placement. Indent or center a displayed equation in the line immediately following the first text reference to it. Break equations before an equal, plus, or multiplication sign. Align a group of separate but related equations by the equal signs and indent or center the group as a whole. Short equations not part of a series may be placed in the text rather than displayed.

Numbering. Number equations which are part of a series or which are referred to in the text consecutively in Arabic numerals; for example (1), (2), (1-1), (2-1), etc. Enclose each number in parentheses at the right margin on the last line of the equation numbers. Number equations within appendices in a manner consistent with the appendix letter, such as (A-1), (B-2), etc.

LISTS.

Lists should be bulleted. If the sequence of items is critical, numerals followed by periods may be used. Begin each entry with a capital letter; end each entry with a period.

GENERAL INFORMATION.

- Numbers from one through nine are spelled out. For numbers 10 and above, use numerals. When a sentence contains numbers below and above 10, numerals are used for each number.

- Numerical compounds. Print a hyphen between the elements of compound numbers from twenty-one to ninety-nine and in adjective compounds with a numerical first element (GPO, page 78, rule 6.36) For example:

  Twenty-one
  6-footer
  24-in ruler
  10-minute delay
  5-to-4 vote
  two-sided question

- Periods and commas should be placed inside quotation marks; semicolons fall outside quotation marks.

- Contractor's organization and author's name(s) may not appear on the cover of the report. The contractor's organization and the report's author(s) shall appear in blocks 7 and 9, respectively, on the Technical Report Documentation Page (form DOT F 1700.7).

- Contractor logos shall not appear in the report.

- When referring to the Federal Government, the words "Federal" and "Government" (whether they appear alone or together) are capitalized. The word "Nation" is capitalized when used as a synonym for the United States (GPO, p. 26, rule 3.19).

- Numbers, units of measurement, or words that depend on each other for meaning should be kept together on the same line of type. For example, Figure 1, 45 percent, chapter 7, 30 mm.

- ABBREVIATIONS

Refer to the United States Government Printing Office (GPO) Style Manual, March 2000. http://www.gpoaccess.gov/stylemanual/browse.html

GPO abbreviations shall be used for units of measurements. Examples follow:

A	ampere
ft	foot
ft^2	square foot
h	hour
HF	high frequency
in	inch
kW	kilowatt
m	meter
p/m	parts per million
r/min	revolutions per minute
r/s	revolutions per second

s second(time)
V volt
VHF very high frequency
W watt

- Do not use periods after these abbreviations.
- Percent should be spelled out in the text. The percent symbol (%) may be used in figures and tables.

COMPOSITION.

- **Software**.

Electronic text files shall be created to be compatible with Microsoft Word (version to be stipulated by the COTR). Non-text files (e.g., presentations, spreadsheets, artwork and imagery) must be included in the programs of origin, so that these files can be modified or corrected if necessary and re-imported into the full text document. These files must be produced in a program that can export an interchange file format that can be imported into the full text document.

If the report involves links, refer to COTR for specific coding instructions.

If a file contains unusual formatting or hidden macros, etc., the contractor should document these for the COTR.

- There are two formatting styles for reports:

1. Straight numbering style: When a report is set up using a straight numbering style, pages, illustrations, tables and equations should be numbered consecutively in Arabic numbers, e.g., pages 1, 2, 3, etc.; figures and tables 1, 2, 3, etc.; equations (1), (2), (3), etc.

2. Chapter-based numbering style: When a report is set up using a chapter-based numbering style, a consistent, chapter-keyed system shall be used; for example, pages 1-1, 2-1, 3-1, figures and tables 1-1, 2-1, 3-1, and equations (1-1) (2-1), (3-1), etc.

Note: For both formatting styles, the Report Front Matter (Notice Page through List of Acronyms) should be numbered consecutively in lower case Roman numerals (e.g., ii, iii, iv, etc). The report cover counts as page i, however, the number is not placed on the cover.

- **Font Type/Size**. Approved fonts are Times New Roman and Courier, 12 point is recommended.

- **Paragraph Format**. For maximum page coverage, do not use block paragraphs. Rather, return all succeeding lines to the left margin. Double space between paragraphs.

- **Line Spacing**. Use one (1) or one-and-one-half (1-1/2) line spacing for reports, except when extra spacing between lines is necessary to assure clarity of run in equations, symbols, etc.

- **Margins**. Use margins of one (1) inch on all sides of pages.

- **Page Numbering**. Number all pages throughout a report consecutively at the bottom center. Odd numbered pages are right-hand pages and even-numbered pages are left-hand pages. Number preliminary pages (Front Matter) in lower case Roman numerals: ii, iii, etc. The cover of the report counts as number one (i), but the number is not placed on the page. Number pages containing main text, illustrations, tables in Arabic numerals: 1, 2, 3, or 1-1, 2-1, etc. Number appendices in alphanumerics: A-1, A-2; B-1, B-2, etc.

  Page numbers should be centered 0.5 inches up from the bottom edge of the page. Page numbers should stand alone (no dash on either side of the number). If a page is prepared in the landscape orientation, the page numbers must be placed in the same location as if the page were in portrait orientation.

  Do not use separate title pages for individual chapters or appendices.

- **Volume Format.** If a report exceeds 400 pages of reproduction copy, it should be divided into two or more volumes. Each volume will be assigned the same R&DC number and publication number separated by a Roman numeral (Volume I, Volume II, etc.) The title and subtitle will appear on the report cover and Technical Report Documentation Page. The abstract of the Technical Report Documentation Page should state that the report is separated into volumes and indicate the subtitle of each volume.

- **Paper Size, Stock, Ink**. 8-1/2" x 11", white recycled paper, black ink.

- **Decorative Features, Company Logos and Advertising**. Advertising displays of any kind shall not appear in the report.

- **Camera-Ready Single-sided Report Original**. The report original shall be single-sided and printed on a laser or letter-quality printer. The use of dot matrix print is not acceptable.

U.S. Coast Guard Research and Development Center
1082 Shennecossett Road, Groton, CT 06340-6048

Report No. (will be filled in by RDC)

PUT THE REPORT TITLE HERE

FINAL REPORT
MONTH YEAR

Prepared for:

U.S. Department of Homeland Security
United States Coast Guard
(Sponsoring Element, e.g., Human Resources)
Washington, DC 20593-0001

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Marc B. Mandler, Ph.D.
Technical Director
United States Coast Guard
Research & Development Center
1082 Shennecossett Road
Groton, CT 06340-6048

Technical Report Documentation Page

1. Report No.	2. Government Accession Number	3. Recipient's Catalog No.

4. Title and Subtitle	5. Report Date MONTH/YEAR
	6. Performing Organization Code Project No. xxxxxxx
7. Author(s)	8. Performing Organization Report No. R&DC UDI # (to be provided by COTR)
9. Performing Organization Name and Address U.S. Coast Guard Research and Development Center 1082 Shennecossett Road Groton, CT 06340-6048	10. Work Unit No. (TRAIS)
	11. Contract or Grant No. ADD
12. Sponsoring Organization Name and Address U.S. Department of Homeland Security United States Coast Guard ADD SPONSOR'S OFFICE Washington, DC 20593-0001	13. Type of Report & Period Covered Final or Interim
	14. Sponsoring Agency Code Commandant (G-)Sponsor 3-ltr designation U.S. Coast Guard Headquarters Washington, DC 20593-0001

15. Supplementary Notes

The R&D Center's technical point of contact is , 860-441- , email:

16. Abstract (MAXIMUM 200 WORDS)

max for abstract is 200 words

17. Key Words	18. Distribution Statement
ADD KEY WORDS	This document is available to the U.S. public through the National Technical Information Service, Springfield, VA 22161

19. Security Class (This Report)	20. Security Class (This Page)	21. No of Pages	22. Price
UNCLASSIFIED	UNCLASSIFIED		

Form DOT F 1700.7 (8/72) Reproduction of form and completed page is authorized.

(SAMPLE) The executive summary provides a **layperson** the information needed to understand what was done, why it needed to be done, and how the work can be used.

EXECUTIVE SUMMARY

When a common petroleum product spills in the marine environment, it begins to evaporate and a flammable atmosphere can form over the spill. U.S. Coast Guard (USCG) Vessel Response Plans (33 CFR 155) require responding vessels to be on site at a spill within two hours after detection and that booms are deployed within one hour. While this rapid response time is needed to minimize the spread of the spill, there is an inherent danger of explosion and fire due to the natural volatility and flammability of the spilled oil and petroleum products. This effort focused on developing a weathering tool which would benefit the Coast Guard by providing the technical foundation and guidance in these situations, and could be used to support a rule-making project for oil spill response vessels, ensuring the safety of response personnel.

Exposure to the marine environment can result in rapid changes to the oil's composition and, consequently, the oil's flammability. An oil slick will remain flammable until it weathers and loses its volatile components. Evaporation is the dominant weathering process responsible for changes in composition during the first few days following a spill. This study employed numerical modeling to examine how the evaporation and flammability characteristics of some representative flammable oils change after a spill in a confined area, such as a boomed area in a harbor. The model results predict how much time must pass from the time of an oil spill until the oil slick is no longer flammable.

The flash point of an oil is the temperature at which there is sufficient airborne concentration of the oil to be ignited by a spark or other ignition source. Flash points are commonly used to assess flammability hazards associated with oils that are transported. The Code of Federal Regulations uses flash points as the basis for grading liquids that are transported. Grade D and E liquids have flash points greater than 26.7 °C (80°F) and are not considered flammable (U.S. Coast Guard, 1997). The flash point alone is not adequate to describe the flammability hazard

associated with an oil in the environment, since the effects of wind and oil thickness can reduce the flammability hazard for oils while on the water. However, flash points are useful indicators of the dangers inherent in handling oils recovered from a spill. If the flash point of an oil is below the ambient temperature, the vapors in a vessel containing the oil may form a fuel-air mixture that can be ignited by a spark or other ignition source.

The numerical model developed for this study was specially constructed for oil slicks confined by booms and in fairly calm waters (i.e., in a harbor.) This model was used to simulate oil evaporation and flash point changes for cases where sufficient mixing from wind and sea occurs to keep the oil homogeneous (well-mixed oils), and for cases where there was no mixing and the conditions are calm. These represent the extremes of mixing that possibly occur in a spill and bound the operational conditions. The time required for some representative flammable oils to weather to Grade D, flash point reaching or exceeding 26.7 °C (80°F), were computed for various conditions of mixing, temperature, and slick thickness. The weathering of five flammable crude oils and gasoline were modeled. It was not necessary to model diesel fuel since it is not a flammable liquid in an unweathered state. The weathering times were generally very sensitive to the thickness and to the level of mixing.

All five stratified crude oils thicker than one centimeter, except Avalon at 30 °C, were predicted to take over 100 hours to weather to Grade D. In contrast, the same five crude oils under well-mixed conditions weathered to Grade D in less than three hours. This study indicated that flammable crude oils in thick slicks under calm conditions lose their volatile components very slowly and remain flammable for days following a spill. Crude oils that spread thin in open-water spills, or those effectively mixed by wave action, lose their volatile components in a matter of hours.

For gasoline, this study predicted that even after most of the gasoline evaporates, it remains a flammable mixture. Given the uncertainties in the models and the variability of gasolines, it seems prudent to treat all weathered gasolines as flammable liquids.

The results of the information obtained in this study will be used to write standards for classifying oil spill response vessels that work in flammable atmospheres during various types of fuel or oil spills. This information indicates how long various crude oils, diesel and gasoline are flammable or explosive after the spill, and therefore, how much precaution must be taken in vessel design to preclude explosions, ignition or fire when the vessel is exposed to vapors.